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IN THE UNITED STATES PATENT & TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

SERIAL NO.: 09/831,334
FILED: January 9, 2002
FOR: ELECTRICALLY CONTROLLED MIRROR FOR A MOTOR
VEHICLE
APPLICANTS: ONNO DIRK OENEMA, PAUL WESSEL POST & MARCO
RAYMOND MARIA NIJMEIJER
ART UNIT: 2872
EXAMINER: MARK A. ROBINSON
CONFIRMATION #: 3239

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Alexandria, VA 22313-1450

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July 25, 2007.

7/25/07
Date
Teresa Bonnell
Teresa Bonnell

FOURTH SUPPLEMENTAL APPEAL BRIEF

Sir:

Responsive to the Notification of Non-Compliant Appeal Brief mailed on June 28, 2007, Appellants submit this Fourth Supplemental Appeal Brief to comply with 37 CFR 41.37.

REAL PARTY IN INTEREST

Eaton Corporation, as Assignee of the entire interest of the present application, is the real party in interest.

RELATED APPEALS AND INTERFERENCES

A prior Appeal for this case was assigned Appeal No. 2006-3187 on September 13, 2006. The Board issued a Remanding Order for Appeal No. 2006-3187 (attached as Appendix B) on March 22, 2007, and requested submission of a subsequent Appeal Brief from Appellants.

There are no other related appeals or Interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

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98-IKU-837

STATUS OF THE CLAIMS

Claims 1 through 26 have been cancelled.

Claims 27 through 31 stand finally rejected and are being appealed. A listing of all of the claims and their current status is included in the Claims Appendix.

STATUS OF AMENDMENTS

Appellants filed an amendment under 37 CFR 1.116 on January 5, 2005 to make corrections suggested by the Examiner. The Examiner entered the Amendment in an Advisory Action dated January 26, 2005, but left the status of the claims unchanged.

SUMMARY OF CLAIMED SUBJECT MATTER

Independent claim 27 is directed to an electrically controlled mirror assembly for a motor vehicle. The assembly includes a mirror housing having a build-up element 1 that defines a hollow 3 and that has a reinforcing element molded therein (Figures 1 and 2; page 7, lines 27-33). A base or support 7 supports the build-up element 1 with a electromechanical means, such as a motor 9, that folds or rotates the mirror housing relative to the support (Figure 3; page 8, lines 10-24). The electromechanical means also can adjust a mirror plate 22 relative to the housing (Figure 3; page 7, lines 29-33). An electrically operable means, such as an electronics unit 2, may be included to direct current through cores 17, 18, 19, 20, 21 to control an ancillary component, such as lighting from a puddle light 33, mirror heating, and/or electrochrome dimming (Figures 2 and 3, page 9, lines 16-23). An electronics unit is disposed in the hollow 3 to control energization of the electromechanical means (Figure 3; page 9, lines 23-35).

Independent claim 31 is directed to a method of making an electrically controlled mirror by providing a support 7, forming a mirror housing with a single build-up element 1 having a hollow 3 and a reinforcing element, mounting the housing on the support and a mirror on the housing, disposing an electromechanical drive means 9 in the housing for moving the housing and the mirror, and disposing an electronics unit in the hollow for controlling movement of the mirror housing on the support and movement of the mirror on the housing.

98-IKU-837

GROUND OF REJECTION TO BE REVIEWED ON APPEAL

(1) Claims 27-30 stand rejected under 35 U.S.C. 103(a) as being obvious over U.S. Patent No. 5,990,999 to Huizenga et al. ("Huizenga") in view of U.S. Patent No. 6,247,823 to Fuerst et al. ("Fuerst").

(2) Claim 31 stands rejected under 35 U.S.C. 103(a) as being obvious over Huizenga in view of Fuerst.

ARGUMENT

(1) Claims 27-30 are patentable under 35 USC 103(a) over Huizenga and Fuerst

The Examiner rejected claims 27-30 as being unpatentable over Huizenga and Fuerst. The Examiner asserted that "the molded conducting strips taught by Huizenga will inherently provide a degree of reinforcement to the build-up element, thus satisfying the claimed limitation" (Final Rejection, p. 4). Appellant respectfully disagrees.

"The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. . . . In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art." MPEP 2112.

In this case, the examiner has not provided any reasoning or evidence showing that the electrical leads 68, 70, 72, 74 formed on the housing member 19 in Huizenga necessarily increase the strength and rigidity of the housing element 19. As is known in the art, thin metal conductors, such as wires, are often flexible and not rigid. Moreover, as shown in Figures 8 and 9, the material used for the housing 19 may be made thinner to accommodate the thickness of the electrical leads 74, thereby potentially reducing the strength of the housing 19. At best, the housing 19 acts as a stiffening support for the leads 68, 70, 72, 74, not the other way around (see, e.g., col. 7, lines 38-55).

In the Examiner's Answer dated November 22, 2005, the Examiner argued that when brass or copper conductors are molded into an element as taught by Huizenga, the higher tensile strength of the metal in the conductors will inherently provide some measure of increased rigidity and strength along at least one dimension of the housing element 19 (p. 7). Appellant respectfully disagrees.

The Examiner correctly noted that one embodiment of the claimed invention (i.e.,

98-IKU-837

claim 28) recites the reinforcing elements as being conductive strips. However, contrary to the Examiner's assertion, this does not automatically mean that incorporating metal strips in a plastic member will reinforce the member. The specification notes that, in one embodiment, the strip shaped conductor is folded over more than once and in different ways, depending on where it is located in the build-up element, to increase the rigidity and strength of the element (page 7, lines 16-28). Thus, it is clear that a metal conductor cannot be considered a reinforcement element solely because it has a higher tensile strength than plastic.

The Examiner appears to use the terms "tensile strength" and "rigidity" interchangeably when they clearly refer to different material characteristics. As is known in the art, a material with a high tensile strength may stretch and deform a great deal before breaking (i.e., have high ductility, and therefore low rigidity). A high tensile strength material can easily have less rigidity than a lower tensile strength material, particularly if it is a ductile material like copper or another conductive metal. Thus, a material with a high tensile strength does not necessarily mean that it can also increase the rigidity of a material having a lower tensile strength. Applicant has attached Appendix B to support these assertions. Appendix B explains how high tensile strength corresponds with high ductility and how ductility and rigidity are opposing characteristics.

Col. 7, lines 51-55 in Huizenga explains that molding the leads 68, 70, 72, 74, the wires 84, 84 and 88, and their connections 92 in the housing 19 eliminates vibrations that could potentially jeopardize a conventional connection (which would flex and move without the support of the housing 19). This interpretation is consistent with the fact that the higher tensile strength (and resulting greater flexibility) of the conductors require the support of the stiffer housing 19 to ensure that vibrations do not flex the wires and break the connections 92.

The simple fact that Huizenga shows conductors on a housing, without more, cannot render the claimed invention obvious. The Examiner has not shown that placing electrical leads made of high tensile strength material on an element necessarily increases the rigidity and strength of that element, particularly when a high tensile strength material

98-IKU-837

stretched into a wire is so inherently flexible and can be so soft that it adds nothing to the rigidity of the housing. Nothing in Huizenga indicates that the electrical leads add any rigidity or strength of the housing 19. Instead, Huizenga clearly shows the opposite, that the leads need the rigidity of the housing 19 to protect them from damage due to vibrations. At best, the rigidity and strength of the housing 19 is dictated by the housing material, with the leads having virtually no effect on the rigidity of the housing. Thus, the metal leads in Huizenga do not teach or suggest the claimed reinforcing element.

The Examiner also admitted that Huizenga does not disclose the claimed electromechanical means or the claimed electronics unit, but argued that it would have been obvious to include an electronics unit in a hollow of a mirror-build-up element as taught by Fuerst to protect the electronics unit. The Examiner also clarified that Fuerst is relied upon for teaching a printed circuit board. Appellant thanks the Examiner for the clarification. Appellant notes that adding Fuerst to Huizenga still fails to render the claimed invention obvious because Fuerst does not show a reinforcement insert at all. Because neither Huizenga nor Fuerst shows the claimed reinforcement element insert in the build-up element, the final rejection of claims 27-30 should be withdrawn.

(2) Claim 31 is patentable under 35 USC 103(a) over Huizenga and Fuerst

Independent method claim 31 recites steps that include insert molding a reinforcement in the build-up element of the mirror housing, disposing an electromechanical drive means on the mirror housing, and disposing an electronics unit in a hollow in the mirror housing. As explained above, neither Huizenga nor Fuerst disclose incorporating a reinforcement element of any kind into a mirror assembly, and there is no motivation to combine Huizenga with Fuerst. The final rejection of claim 31 is therefore improper and should be withdrawn.

98-IKU-837

Accordingly, it is requested that the Board reverse the Examiner's rejection and allow the claims to be issued.

Respectfully submitted,



Dated: 07/25/2007

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98-IKU-837

CLAIMS APPENDIX

1. (Cancelled) An electrically controlled mirror for a motor vehicle, provided with a support to be mounted on a vehicle for a mirror housing having a mirror plate movable in said mirror housing and electromechanical means for adjusting the mirror housing relative to the support and the mirror plate relative to the mirror housing, and with any means for accommodating one or more other functions, such as mirror heating, electrochrome dimming of light falling on the mirror plate, various lighting functions, remote control means, etc. in the mirror housing, characterized in that the mirror housing comprises one single build-up element on which said means are provided, in which build-up element a reinforcement element is provided for increasing the rigidity and strength of the build-up element.
2. (Cancelled) An electrically controlled mirror according to claim 1, characterized in that the build-up element forms one whole and is manufactured from a plastic, the reinforcement element being made of metal and insert-molded, in wholly or partially folded condition, in the plastic build-up element.
3. (Cancelled) An electrically controlled mirror according to claim 2, characterized in that the reinforcement element forms a multi-core electric conductor for the functions to be realized in the mirror housing by said means.
4. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that the build-up element has a space in which an electronics unit for controlling the various functions is accommodated.
5. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that the build-up element has a space for the means for adjusting the mirror plate relative to the mirror housing.
6. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that the build-up element has one space for both the electronics unit for controlling the various functions and the means for adjusting the

98-IKU-837

mirror plate relative to the mirror housing.

7. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that the build-up element has a space in which, in cooperation with a space in a mounting base element in the support, the means for adjusting the mirror housing relative to the support are accommodated.
8. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that the build-up element has one or more further spaces for lighting means.
9. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that the electric conductor comprises an input conductor with two feed lines and at least one data line.
10. (Cancelled) An electrically controlled mirror according to claim 9, characterized in that over the data line or lines, digital serial information is passed on multiplex basis from the vehicle to the electronics unit and control signals are provided by this electronics unit over relevant cores in the electric conductor for controlling the various components in the mirror housing.
11. (Cancelled) An electrically controlled mirror according to any one of the preceding claims, characterized in that via the space in the mounting base element in the support, the cable work of the mirror can be connected from the vehicle to the electric conductor integrated into the build-up element.
12. (Cancelled) An electrically controlled mirror according to claim 11, characterized in that the connection of the cable work from the vehicle to the electric conductor extends through the shaft via which shaft the mirror housing can rotate relative to the support on the vehicle.
13. (Cancelled) An electrically controlled mirror according to claim 12, characterized

98-IKU-837

in that in said shaft a connector is provided to which the cable work from the vehicle is connected and that the electric conductor comprises a plug which, when the build-up element is being slid over the mounting base element, is plugged into the connector.

14. (Cancelled) An electrically controlled mirror according to claims 5 and 6, characterized in that the means for adjusting the mirror plate relative to the mirror housing are provided on a mounting plate and that the space for these means comprises projecting, pin-shaped parts which form one whole with the build-up element and on which the mounting plate can be secured by a clip connection.

15. (Cancelled) An electrically controlled mirror according to claim 14, characterized in that the clip connection is obtained by a clip fixedly provided on the mounting plate.

16. (Cancelled) An electrically controlled mirror according to claim 14, characterized in that the pin-shaped parts comprise a widened portion and, adjacent the free end, a narrowed portion, the mounting plate which has been slid over the narrowed portion being clamped between the top edge of said widened portion and a cover element present for the driving means for adjusting the mirror plate, which driving means are to be provided on the mounting plate, the cover element being secured by a clip connection.

17. (Cancelled) An electrically controlled mirror according to claim 16, characterized in that the clip connection is obtained by a clip fixedly provided on the cover element.

18. (Cancelled) An electrically controlled mirror according to any one of claims 14-17, characterized in that the electronics unit for controlling the various functions is provided on the mounting plate.

19. (Cancelled) An electrically controlled mirror according to claim 14, characterized in that at least a part of the electronics of the electronics unit is located on the other side of the mounting plate where the means for adjusting the mirror plate relative to the mirror housing are provided.

98-IKU-837

20. (Cancelled) An electrically controlled mirror assembly for a motor vehicle comprising:
- (a) a support adapted for mounting on a vehicle;
 - (b) a mirror housing moveably associated with said support;
 - (c) a mirror plate moveably associated with said housing;
 - (d) electromechanical means operable upon energization for adjusting said housing relative to said support and said mirror plate relative to said housing; and,
 - (e) means operable upon electrical energization for performing ancillary function, wherein said mirror housing comprises one piece element formed of non-conductive material with reinforcing elements insert molded therein and defining a hollow; and,
 - (f) an electronics unit received in said hollow for controlling said energization.
21. (Cancelled) The assembly defined in claim 20, wherein said reinforcing elements comprise electrically conductive strips.
22. (Cancelled) The assembly defined in claim 20, wherein said electronic unit includes a printed circuit board.
23. (Cancelled) The assembly defined in claim 20, wherein said one-piece element includes pin-shaped portions; and, said means for adjusting the mirror plate relative to the housing includes a mounting plate secured to said pin-shaped portions.
24. (Cancelled) The assembly defined in claim 20, wherein said support includes a mounting base having a hollow shaft adapted for having electrical cables pass therethrough.

98-IKU-837

25. (Cancelled) A method of making an electrically controlled mirror for a motor vehicle comprising;
- (a) providing a support;
 - (b) forming a one-piece mirror housing of non-conductive material and insert molding electrically conductive reinforcement strips therein and forming a hollow therein;
 - (c) moveably mounting the housing on the support and moveably mounting a mirror on the housing;
 - (d) disposing electromechanical drive means on said housing and moving the mirror; and,
 - (e) disposing an electronics unit in said hollow for controlling the moving.
26. (Cancelled) The method defined in claim 25, wherein said step of forming a one-piece housing includes molding plastic.
27. (Rejected and appealed) An electrically controlled mirror assembly for a motor vehicle comprising:
- (a) a support adapted for mounting on a vehicle;
 - (b) a mirror housing moveably associated with said support comprising a single build-up element formed of non-conductive material with a reinforcing element insert molded therein for increasing the rigidity and strength of the build-up element, said build-up element defining a hollow;
 - (c) a mirror plate moveably associated with the housing;
 - (d) electromechanical means operable upon energization for adjusting said housing relative to said support and for adjusting said mirror plate relative to said housing;
 - (e) means operable upon electrical energization for performing an ancillary function; and,
 - (f) an electronics unit received in said hollow for controlling said energization for said adjusting.

98-IKU-837

28. (Rejected and appealed) The assembly defined in claim 27, wherein said reinforcing elements comprise electrically conductive strips.
29. (Rejected and appealed) The assembly defined in claim 27, wherein said electronic unit includes a printed circuit board.
30. (Rejected and appealed) The assembly defined in claim 27, wherein said support includes a mounting base having a hollow shaft adapted for having electrical cables pass therethrough.
31. (Rejected and appealed) A method of making an electrically controlled mirror for a motor vehicle comprising:
- (a) providing a support;
 - (b) forming a mirror housing comprising a single build-up element of non-conductive material and insert molding therein a reinforcement for increasing rigidity and strength of the build-up element;
 - (c) forming a hollow in said build-up element;
 - (d) mounting the housing on the support for movement thereon and mounting a mirror on the housing for movement thereon;
 - (e) disposing electromechanical drive means on said housing for effecting said movement; and,
 - (f) disposing an electronics unit in said hollow for controlling the movement of said mirror housing on said support and the movement of said mirror on said housing.

98-IKU-837

EVIDENCE APPENDIX

Applicant has not submitted any evidence under 37 CFR §§ 1.130, 1.131, or 1.132 in this application.

98-IKU-837

RELATED PROCEEDINGS APPENDIX

This case was previously appealed. Appellants filed an Appeal Brief on August 5, 2005, and the Examiner responded with an Examiner's Answer on November 22, 2005. The Board issued a Remanding Order on January 26, 2007, a copy of which is attached as Appendix A. There are no other decisions that will affect or be affected by the outcome of this appeal.

98-IKU-837

APPENDIX A

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The opinion in support of the decision being entered today was *not* written for publication and is *not* binding precedent of the Board.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte Onno Dirk Oenema, Paul Wessel Post, and
Marco Raymond Maria Nijmeijer

Appeal No. 2006-3187
Application No. 09/831,334

ON BRIEF

Before DIXON, BARRY, and SAADAT, *Administrative Patent Judges*.
DIXON, *Administrative Patent Judge*.

ORDER REMANDING TO THE EXAMINER

This is an Order remanding this application to the Examiner. From our initial review of the application and prosecution history, we note a number of items and issues that need to be addressed and clarified by Appellants and the Examiner prior to our decision on the merits.

Appeal No. 2006-3187

Application No. 09/831,334

First, we note that Appellants' Brief is non-compliant with respect to 37 CFR 41.37(c)(1)(v) Summary of claimed subject matter. With respect to independent claim 27, Appellants state:

Independent claim 27 is directed to an electrically controlled mirror assembly for a motor vehicle. The assembly includes a mirror housing having a build-up element 1 that defines a hollow 3 and that has a reinforcing element molded therein (Figures 1 and 2; page 7, lines 27-33). A base or support 7 supports the build-up element 1 with a electromechanical means, such as a motor 9, that folds or rotates the mirror housing relative to the support (Figure 3; page 8, lines 10-24). The electromechanical means also can adjust a mirror plate 22 relative to the housing (Figure 3; page 7, lines 29-33). An electronics unit is disposed in the hollow 3 to control energization of the electromechanical means (Figure 3; page 9, lines 23-35).

Claim 27 recites:

27. An electrically controlled mirror assembly for a motor vehicle comprising:
- (a) a support adapted for mounting on a vehicle;
 - (b) a mirror housing moveably associated with said support comprising a single build-up element formed of non-conductive material with a reinforcing element insert molded therein for increasing the rigidity and strength of the build-up element, said build-up element defining a hollow;
 - (c) a mirror plate moveably associated with the housing;
 - (d) electromechanical means operable upon energization for adjusting said housing relative to said support and for adjusting said mirror plate relative to said housing;
 - (e) means operable upon electrical energization for performing an ancillary function; and,
 - (f) an electronics unit received in said hollow for controlling said energization for said adjusting.

We note that Appellants' brief is silent as to the corresponding structure acts or materials for performing function "(e) means operable upon

Appeal No. 2006-3187
Application No. 09/831,334

electrical energization for performing an ancillary function.” Therefore, Appellants’ brief is non-compliant and a new brief is required. Therefore, the Examiner should require a new brief with a correct Summary of the claimed subject matter.

As an additional note from our cursory review of Appellants’ specification, we note that the specification seems to only describe the structures for performing ancillary functions in terms of “means” rather than an actual structure which would perform the function. We leave it to the Examiner to further consider, after Appellants identify the corresponding structure, acts and materials in the specification, whether this disclosure is sufficient under 35 U.S.C. § 112, First and Second Paragraphs with the recited “(e) means operable upon electrical energization for performing an ancillary function.” The Examiner is required to take appropriate action as needed.

Any subsequent brief submitted by the appellants should be self-contained with respect to all arguments. No prior brief should be referenced or incorporated therein. Similarly, any subsequent Examiner’s Answer should be self-contained with respect to all rejections and arguments; no prior answer or Office action should be referenced or incorporated therein.

Because it is being remanded for further action, the application is a “special” application. M.P.E.P. § 708.01(D). Accordingly, it requires immediate action. Furthermore, the Board should be informed promptly of any action affecting status of the appeal (e.g., abandonment, issue, reopening prosecution).

Appeal No. 2006-3187
Application No. 09/831,334

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98-IKU-837

APPENDIX B

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tensile strength

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On this page:

Dictionary

tensile strength

Dictionarytensile strength
n. (Abbr. TS)

The resistance of a material to a force tending to tear it apart, measured as the maximum tension the material can withstand without tearing.

ASTM Standards - Download

Techstreet sells over 15,000 ASTM standards for immediate download.
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Tensile Strength

Search Test & Measurement Vendors- Compare Product Specifications
www.globalspec.com

WordNet

Note: click on a word meaning below to see its connections and related words.

The *noun* tensile strength has one meaning:

Meaning #1: the strength of material expressed as the greatest longitudinal stress it can bear without tearing apart

SectionCalc wizard

Delivers all 14 section properties of any CAD x-section in one step.
www.sectioncalc.com

Extensometers

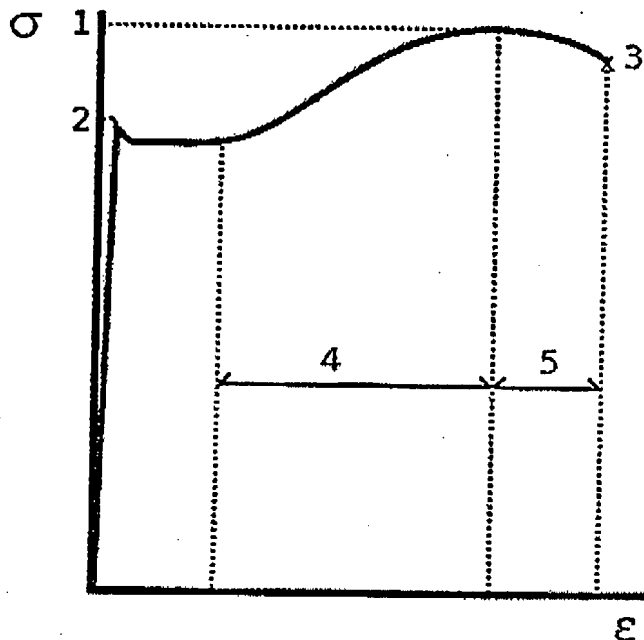
Epsilon Technology Corp strain sensors for material testing
www.epsilontech.com

Wikipedia

tensile strength

- **Yield Strength** - The stress a material can withstand without permanent deformation.
- **Ultimate Strength** - The maximum stress a material can withstand.
- **Breaking Strength** - The stress coordinate on the Stress-strain curve at the point of rupture.

The various definitions of tensile strength are shown in the the following stress-strain graph for low-carbon steel:



Stress vs. Strain curve typical of structural steel

1. Ultimate Strength
2. Yield Strength
3. Rupture
4. Strain hardening region
5. Necking region.

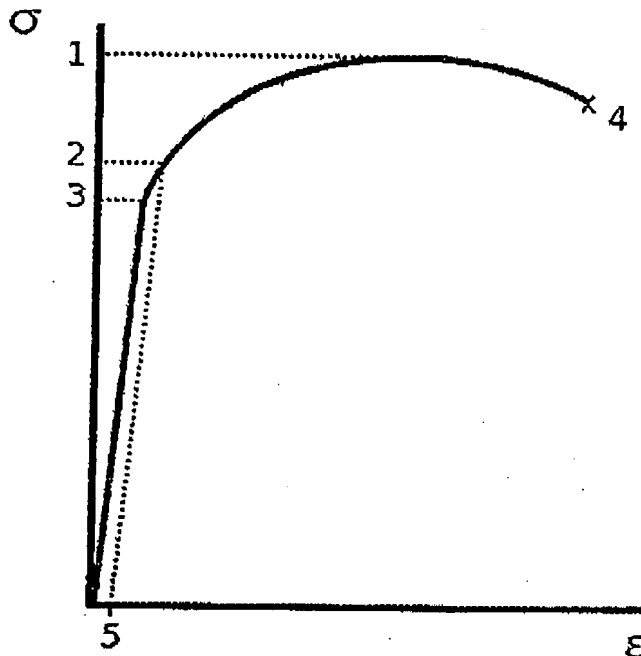
Steel has a very linear stress-strain relationship up to a sharply defined yield point, as shown in the figure.

For stresses below this yield strength all deformation is recoverable, and the material will relax into its initial shape when the load is removed. For stresses above the yield point, a portion of the deformation is not recoverable, and the material will not relax into its initial shape. This unrecoverable deformation is known as plastic deformation. For many applications plastic deformation is unacceptable, and the yield strength is used as the design limitation.

After the yield point, steel and many other ductile metals will undergo a period of strain hardening, in which the stress increases again with increasing strain up to the *ultimate strength*. If the material is unloaded at this point, the stress-strain curve will be parallel to that portion of the curve between the origin and the yield point. If it is re-loaded it will follow the unloading curve up again to the ultimate strength, which has become the new yield strength.

After steel has been loaded to its ultimate strength it begins to "neck" as the cross-sectional area of the specimen decreases due to plastic flow. Necking is accompanied by a region of decreasing stress with increasing strain on the stress-strain curve. After a period of necking, the material will rupture and the stored elastic energy is released as noise and heat. The stress on the material at the time of rupture is known as the *breaking stress*. Note that if the graph is plotted in terms of *true stress* and *true strain* necking will not be observed on the curve as true stress is corrected for the decrease in cross-sectional area. Necking is also not observed for materials loaded in compression.

Ductile metals other than steel typically do not have a well defined yield point. For these materials the yield strength is typically defined by the "0.2% offset strain". The yield strength at 0.2% offset is determined by finding the intersection of the stress-strain curve with a line parallel to the initial slope of the curve and which intercepts the abscissa at 0.002. A stress-strain curve typical of Aluminum along with the 0.2% offset line is shown in the figure below.

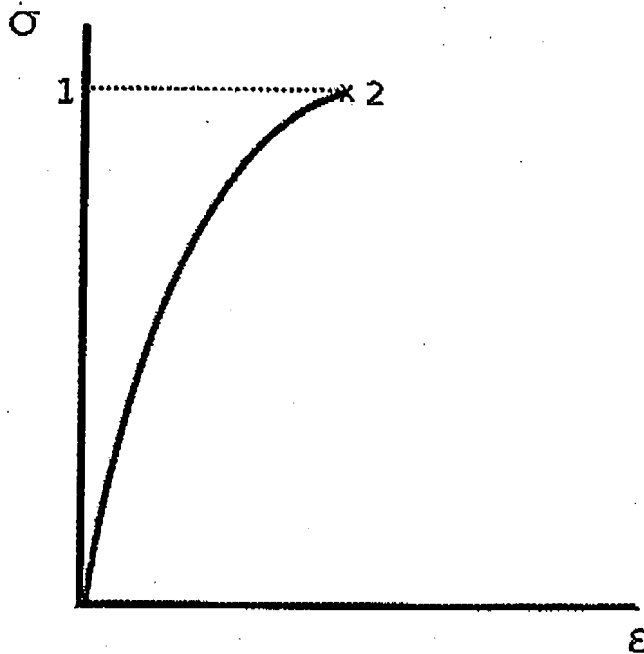


Stress vs. Strain curve typical of aluminum

1. Ultimate Strength
2. Yield Strength
3. Proportional Limit Stress
4. Rupture

5. Offset Strain (typically 0.002).

Brittle materials such as concrete and carbon fiber do not have a yield point, and do not strain-harden which means that the ultimate strength and breaking strength are the same. A stress-strain curve for a typical brittle material is shown in the figure below.



Stress vs. Strain curve typical of a brittle material

1. Ultimate Strength
2. Rupture.

Tensile strength is measured in units of force per unit area. In the SI system, the units are newtons per square metre (N/m^2) or pascals (Pa), with prefixes as appropriate. The non-metric units are pounds-force per square inch (lbf/in^2 or PSI).

The breaking strength of a rope is specified in units of force, such as newtons, without specifying the cross-sectional area of the rope. This is often loosely called tensile strength, but this not a strictly correct use of the term.

In brittle materials such as rock, concrete, cast iron, or soil, tensile strength is negligible compared to the compressive strength and it is assumed zero for most engineering applications. Glass fibers have very high tensile strength, but bulk glass usually does not.

Tensile strength can be measured for liquids as well as solids. For example, when a tree draws water from its roots to its upper leaves by transpiration, the column of water is pulled upwards from the top by capillary action, and this force is transmitted down the column by its tensile strength. Air pressure from below also plays a small part in a tree's ability to draw up water, but this alone would only be sufficient to push the column of water to a height of about ten metres, and trees can grow much higher than that. (See also cavitation, which can be thought of as the consequence of water being "pulled too hard".)

Typical tensile strengths

Some typical tensile strengths of some materials:

Material	Yield strength (MPa)	Ultimate strength (MPa)	Density (g/cm ³)
Structural steel ASTM-A36	250	400	
Steel, high strength alloy ASTM A-514	690	760	
Steel, high tensile	1650	1860	
Piano wire		2000	
Polypropylene	12-43	19.7-80	
Stainless steel AISI 302 - Cold-rolled	520	860	
Cast iron 4.5% C, ASTM A-48	-	170	
Titanium Alloy (6% Al, 4% V)	830	900	4.51
Aluminum Alloy 2014-T6	400	455	2.7
Copper 99.9% Cu	70	220	8.92
Cupronickel 10% Ni, 1.6% Fe, 1% Mn, balance Cu	130	350	8.94
Brass		250	
Glass (St Gobain "R")	4400 (3600 in composite)		2.53
Marble	-	15	
Concrete	-	3	
Spider silk	1150 (??)	1200	
Silkworm silk			
Kevlar	3620		1.44
Vectran		2850-3340	
Pine Wood (parallel to grain)		40	
Bone (limb)		130	
Nylon, type 6/6	45	75	
Rubber	-	15	
Boron	3100		2.46
Silicon carbide (SiC)	3440		
Sapphire (Al ₂ O ₃)	1900		3.9-4.1

Single-walled carbon nanotubes have the highest tensile strength of any material yet measured, with the highest single measurement of a nanotube being 63 GPa (63000 MPa). As of 2004, however, no macroscopic object constructed using a nanotube-based material has had a tensile strength remotely approaching this figure, or substantially exceeding that of high-strength materials like Kevlar.

Sources

- Giancoli, Douglas. *Physics for Scientists & Engineers Third Edition*. Upper Saddle River: Prentice Hall, 2000.
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Further information

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- [Vertical strength](#)
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- [Tensile Strength Test](#)
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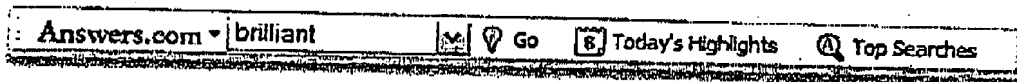


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1. The property of a metal which allows it to be drawn into wires or filaments.
2. Tractableness; pliability. —South.

Source: Webster's Revised Unabridged Dictionary (1913)

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Rigidity \Riˈgidɪˈti/, n. [L. rigiditas: cf. F. rigidité]. See Rigid.]

1. The quality or state of being rigid; want of pliability; the quality of resisting change of form; the amount of resistance with which a body opposes change of form; — opposed to flexibility, ductility, malleability, and softness.

2. Stiffness of appearance or manner; want of ease or elegance. —Sir H. Wotton.

3. Severity; rigor. [Obs. or R.]

—Bp. Burnet.

Syn: Stiffness; rigidness; inflexibility.

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